REPORT DOCUMENTATION PAGE

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Service, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT DATE	3. DATES COVERED *(From - To)*
10/15/1999	10/15/99	5/99 - 9/99

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Data Provisioning Systems for Autonomous Vehicles	
	5b. GRANT NUMBER N00014-98-1-0695-04/02
	5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)	5d. PROJECT NUMBER
Prof. Pravin Varaiya	
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
University of California, Berkeley Electronics Research Laboratory 253 Cory Hall, Berkeley, CA 94720-1770	442427-23132

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
Office of Naval Research, Program Officer Allen Moshfegh ONR 351, Ballston Centre Tower One 800 North Quincy Street Arlingont, VA 22217-5660	
	11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

19991022 068

14. ABSTRACT

This project is part of a "portfolio" comprising four other projects to investigate the possibility of operating a collection of intelligent autonomous agents so that the collection can understake complex missions. To determine this, we are testing a new routing algorithm in which nodes are known by their geographical address. In additional, we have developed a MAC layer protocol for forming a "ring" network among nearby agents. Finally we are formulating a mathematical problem that captures the essence of data provisioning based on the work of John Chuang and recent developments in teh Internet known as "layer 5" switching and "content ditribution networks."

15. SUBJECT TERMS

Data Provisioning Systems
Autonomous Vehicles

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Prof. Pravin Varaiya
unlimited					**19b. TELEPONE NUMBER** *(Include area code)* (510) 642-5270

DTIC QUALITY INSPECTED 4

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI-Std Z39-18

Data Provisioning Systems for Autonomous Vehicles

PI. Pravin Varaiya

Progress Report for Period 5/99 – 9/99

Summary

This is the progress report of the project, *Data Provisioning Systems*, for the 5-month period May 1999 - September 1999.

Research advanced in several domains: (1) architecture of data provisioning systems; (2) geographical routing for *ad hoc* networks; and (3) medium access control protocols for "ring networks" with hidden terminals.

The tangible products of the research are:

- A preliminary architecture of the communication networks that can support the data/information needs for systems of autonomous vehicles engaged in complex missions;

- A preliminary algorithm for geographical-based routing of packets through a wireless *ad hoc* network that appears to be superior to existing routing algorithms along several performance metrics;

- A preliminary medium access control (MAC) protocol for wireless ring networks that is compatible with IEEE 802.11 standards.

Objective

It seems possible to operate a collection of intelligent autonomous agents so that the collection can undertake complex missions. The intelligence of the system resides to a significant extent in the organization. The organization can accomplish missions that individual agents cannot. The organization coordinates the decisions taken by the various agents. To carry out this coordination requires an "infrastructure" that meets the agents' needs for data and for communication. We call this infrastructure a Data Provisioning System (DPS). The objective of this project is to conduct research in the design of DPS.

This project is part of a "portfolio" comprising four other projects. Andrea Goldsmith's project is concerned with characterizing the channels (physical layer) that are likely to be encountered in these missions. Martha Steenrup's project deals with routing. P.R. Kumar's research seeks to evaluate the total capacity of these networks.

Results to date

Geographical Routing. We are testing a new routing algorithm in which nodes are known by their geographical address. The algorithm requires routing table of the size of log n, if there are n nodes. This is significantly smaller than the algorithms published in the literature. We are developing a set of performance metrics for comparing alternative algorithms.

MAC layer protocols. We have developed a MAC layer protocol for forming a "ring" network among nearby agents. The advantage of a "ring" is the guaranteed performance (in terms of latency and bandwidth). The protocol permits new agents to be added to the ring, and others to be removed. We are formally specifying the algorithm so that correctness can be proved.

Data Provisioning. Based on the work of John Chuang and recent developments in the Internet known as "layer 5" switching and "content distribution networks" we are formulating a mathematical problem that captures the essence of data

provisioning in our context. The mathematical problem displays the tradeoff between bandwidth availability and early provisioning.